IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Ulrich STEINBRENNER et al

Based on PCT/DE 01/01720

For: METHOD FOR OPERATING A FUEL METERING SYSTEM OF A DIRECT-INJECTION INTERNAL COMBUSTION ENGINE

PRELIMINARY AMENDMENT

Commissioner For Patents
Washington, D.C. 20231

Sir:

Prior to examination, please amend the above-identified application as follows:

IN THE SPECIFICATION

Page 1, between the title and paragraph [0001], insert the following:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This application is a 35 U.S.C. 371 application of PCT/DE 01/01720, filed May 8, 2001.

[0000.6] BACKGROUND OF THE INVENTION

replace paragraph [0001], with the following amended paragraph:

[0001] Field Of The Invention

Page 3, between paragraphs [0005] and [0006], insert the new paragraph:

[0005.5] DESCRIPTION OF THE PRIOR ART

Page 7, replace paragraph [0013] with the following amended paragraph:

[0013] SUMMARY OF THE INVENTION

Page 12, delete paragraph [0024]:

Page 14, replace paragraph [0030] with the following amended paragraph:

[0030] BRIEF DESCRIPTION OF THE DRAWINGS

replace paragraph [0031] with the following amended paragraph:

[0031] Further characteristics, possible applications, and advantages of the invention will become apparent from the ensuing description of exemplary embodiments of the invention, taken in conjunction with the drawings, in which

Page 15, between paragraphs [0037] and [0038], insert the new paragraph:

[0037.5] DESCRIPTION OF THE PREFERRED EMBODIMENTS

Page 17, replace paragraph [0042] with the following amended paragraph:

[0042] The high-pressure reservoir 16 is embodied as a storage strip of a common rail (CR) fuel metering system. A pressure sensor is disposed on the high-pressure

reservoir 16; it detects the injection pressure prevailing in the high- pressure reservoir 16 and generates a corresponding output signal P_r. From the high-pressure reservoir 16, a plurality of injection valves 9 - in the present case, four of them - branch off, by way of which fuel is injected into the combustion chambers 4 of the cylinders 3 of the engine 1. For injection of fuel, the injection valves 9 are triggered by a suitable trigger signal ES. The spark plug 10 is triggered by a trigger signal ZW.

Page 20, replace paragraph [0048] with the following amended paragraph:

[0048] Both high-pressure pumps 14, 15 are disposed in this single fuel circuit. Both high-pressure pumps 14, 15 are triggered independently of one another by the control unit 22 via a common pressure regulating circuit. For economy of operation, in terms of resources, of the fuel metering system 11, both high-pressure pumps 14, 15 are triggered with the same triggering time signal T. The triggering time signal T is accordingly calculated once and for all in the control unit 22 for both high-pressure pumps 14, 15.

Page 22, replace paragraph [0053] with the following amended paragraph:

[0053] Fig. 3 shows a triggering of the high-pressure pumps 14, 15 of the fuel metering system 11 of Fig. 2 in accordance with a preferred embodiment. In the upper half of Fig. 3, the stroke h_1 of the high-pressure pump 14 is shown, and in the lower part, the stroke h_2 of the high-pressure pump 15 is shown. It is clearly seen that the two high-pressure pumps 14, 15 are triggered oppositely from one another. It can also be

learned from Fig. 3 when the pump pistons of the high-pressure pumps 14, 15 execute an intake stroke, or when they pump fuel into the high-pressure reservoir 16 in a pumping stroke.

Page 24, after paragraph [0055] insert the following new paragraph:

[0056] The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

Page 25, Line 1, delete "Claim" and insert–"We Claim"--.

IN THE CLAIMS

Please cancel claims 1-17 and add new claims 18-48.

18. A method for operating a fuel metering system (11) of a direct-injection internal combustion engine (1) in which the fuel metering system has a fuel supply container (12), at least one prefeed pump (13) for pumping fuel out of the fuel supply container (12) into a low-pressure region (ND) of the fuel metering system (11), a high-pressure pump assembly having at least two high-pressure pumps (14, 15) for pumping fuel out of the low-pressure region (ND) into at least one high-pressure reservoir (16; 16', 16''), a control unit (22) for regulating an injection pressure (P_r) prevailing in the high-pressure reservoir (16; 16', 16''), and fuel injection valves (9) for injecting fuel out of the high-pressure reservoir (16; 16', 16'') into combustion chambers (4) of the engine (1), the method comprising providing the fuel metering system (11) with one fuel circuit for metering fuel into all the combustion chambers (4) of the engine (1), connecting all the high-pressure pumps (14, 15) in the fuel circuit, and triggering all the high-pressure pumps (14, 15) independently of one another via a common pressure regulating circuit.

19. The method of claim 18, wherein the high-pressure pumps (14, 15) are triggered parallel to one another.

20. The method of claim 18, wherein one or more first high-pressure pumps (14) are triggered oppositely from one or more second high-pressure pumps (15).

21. The method of claim 18, wherein the high-pressure pumps (14, 15) are triggered with the same triggering time signal (T).

22. A fuel metering system (11) of a direct-injection internal combustion engine (1), comprising a fuel supply container (12), at least one prefeed pump (13) for pumping fuel out of the fuel supply container (12) into a low- pressure region (ND) of the fuel metering system (11), a high-pressure pump assembly having at least two high-pressure pumps (14, 15) for pumping fuel out of the low-pressure region (ND) into at least one high-pressure reservoir (16; 16', 16"), a control unit (22) for regulating an injection pressure (P_r) prevailing in the high-pressure reservoir (16; 16', 16"), and fuel injection valves (9) for injecting fuel out of the high-pressure reservoir (16; 16', 16") into combustion chambers (4) of the engine (1), the fuel metering system (11) having one fuel circuit for metering fuel into all the combustion chambers (4) of the engine (1), all the high-pressure pumps (14, 15) being disposed in the fuel circuit, and the control unit (22) including one pressure regulating circuit for all the high-pressure pumps (14, 15), the high- pressure pumps (14, 15) being triggerable independently of one another via the pressure regulating circuit.

23. The fuel metering system (11) of claim 22, wherein the high-pressure pump assembly has two high-pressure pumps (14, 15).

24. The fuel metering system (11) of claim 22, wherein the control unit (22) triggers the high-pressure pumps (14, 15) parallel to one another.

25. The fuel metering system (11) of claim 23, wherein the control unit (22) triggers the high-pressure pumps (14, 15) parallel to one another.

26. The fuel metering system (11) of claim 22, wherein the control unit (22) triggers one or more first high-pressure pumps (14) oppositely from one or more second high-pressure pumps (15).

27. The fuel metering system (11) of claim 23, wherein the control unit (22) triggers one or more first high-pressure pumps (14) oppositely from one or more second high-pressure pumps (15).

28. The fuel metering system (11) of claim 22, wherein the control unit (22) triggers the high-pressure pumps (14, 15) with the same triggering time signal (T).

29. The fuel metering system (11) of claim 23, wherein the control unit (22) triggers the high-pressure pumps (14, 15) with the same triggering time signal (T).

30. The fuel metering system (11) of claim 24, wherein the control unit (22) triggers the high-pressure pumps (14, 15) with the same triggering time signal (T).

31. The fuel metering system (11) of claim 25, wherein the control unit (22) triggers the high-pressure pumps (14, 15) with the same triggering time signal (T).

32. The fuel metering system (11) of claim 26, wherein the control unit (22) triggers the high-pressure pumps (14, 15) with the same triggering time signal (T).

33. The fuel metering system (11) of claim 27, wherein the control unit (22) triggers the

high-pressure pumps (14, 15) with the same triggering time signal (T).

34. In a fuel metering system (11) of a direct-injection internal combustion engine (1), including a fuel supply container (12), at least one prefeed pump (13) for pumping fuel out of the fuel supply container (12) into a low- pressure region (ND) of the fuel metering system (11), a high-pressure pump assembly having at least two high-pressure pumps (14, 15) for pumping fuel out of the low-pressure region (ND) into at least one high-pressure reservoir (16; 16', 16"), a control unit (22) for regulating an injection pressure (P_r) prevailing in the high-pressure reservoir (16; 16', 16"), and fuel injection valves (9) for injecting fuel out of the high-pressure reservoir (16; 16', 16") into combustion chambers (4) of the engine (1), the improvement wherein the fuel metering system (11) comprising one fuel circuit for metering fuel into all the combustion chambers (4) of the engine (1), all the high-pressure pumps (14, 15) being disposed in the fuel circuit, and the control unit (22) including one pressure regulating circuit for all the high-pressure pumps (14, 15), the high- pressure pumps (14, 15) being triggerable independently of one another via the pressure regulating circuit..

35. The fuel metering system (11) of claim 34, wherein the high-pressure pump assembly has two high-pressure pumps (14, 15).

36. The fuel metering system (11) of claim 34, wherein the control unit (22) triggers the high-pressure pumps (14, 15) parallel to one another.

37. The fuel metering system (11) of claim 34, wherein the control unit (22) triggers the

high-pressure pumps (14, 15) parallel to one another.

38. The fuel metering system (11) of claim 34, wherein the control unit (22) triggers one or more first high-pressure pumps (14) oppositely from one or more second high-pressure pumps (15).

39. The fuel metering system (11) of claim 34, wherein the control unit (22) triggers one or more first high-pressure pumps (14) oppositely from one or more second high-pressure pumps (15).

40. The engine (1) of claim 34, characterized in that the engine (1) has at least six cylinders (3).

41. The engine (1) of claim 34, wherein the fuel metering system (11) has two high-pressure reservoir regions (16', 16"), which communicate with one another via a pressure equalization line (26).

42. In a control unit (22) for a fuel metering system (11) of a direct-injection internal combustion engine (1), which includes a fuel supply container (12), at least one prefeed pump (13) for pumping fuel out of the fuel supply container (12) into a low-pressure region (ND) of the fuel metering system (11), a high-pressure pump assembly having at least two high-pressure pumps (14, 15) for pumping fuel out of the low-pressure region (ND) into at least one common rail (16; 16', 16"), the control unit (22) for regulating an injection pressure (P_r) prevailing in the high-pressure reservoir (16; 16',

16"), and fuel injection valves (9) for injecting fuel out of the high-pressure reservoir (16; 16', 16") into combustion chambers (4) of the engine (1), the improvement wherein the fuel metering system (11) has one fuel circuit for metering fuel into all the combustion chambers (4) of the engine (1), and all the high-pressure pumps (14, 15) are disposed in the fuel circuit, and that the control unit (22) triggers all the high-pressure pumps (14, 15) independently of one another via a common pressure regulating circuit.

43. The control unit (22) of claim 42, wherein the control unit (22) triggers the high-pressure pumps (14, 15) parallel to one another.

44. The control unit (22) of claim 42, wherein the control unit (22) triggers one or more first high-pressure pumps (14) oppositely from one or more second high-pressure pumps (15).

45. The control unit (22) of claim 42, wherein the control unit (22) triggers the high-pressure pumps (14, 15) with the same triggering time signal (T).

46. The control unit (22) of claim 43, wherein the control unit (22) triggers the high-pressure pumps (14, 15) with the same triggering time signal (T).

47. The control unit (22) of claim 44, wherein the control unit (22) triggers the high-pressure pumps (14, 15) with the same triggering time signal (T).

48. A control element, in particular a read-only memory (ROM) or flash memory, for a control unit (22) of a direct-injection internal combustion engine (1), in which a program is stored in memory that is capable of being run on a computer, in particular a microprocessor, and is suitable for performing a method of claim 18.

IN THE ABSTRACT

Page 31, please substitute the attached Abstract of the Disclosure for the abstract as originally filed.

REMARKS

The above amendments are being made to place the application in better condition for examination.

Entry of the amendment is respectfully solicited.

Respectfully submitted,

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ABSTRACT OF THE DISCLOSURE

The present invention relates to a method for operating a fuel metering system (11) of a direct-injection internal combustion engine, having a fuel supply container, at least one prefeed pump a high-pressure pump assembly having at least two high-pressure pumps for pumping fuel out of the low-pressure region into at least one high-pressure reservoir , a control unit for regulating an injection pressure prevailing in the high-pressure reservoir , and having fuel injection valves for injecting fuel out of the high- pressure reservoir into combustion chambers of the engine. In order especially in engines with large displacement and in engines with more than four cylinders to assure reliable supply of fuel to the combustion chambers, it is proposed that the fuel metering system has one fuel circuit for metering fuel into all the combustion chambers of the engine, and all the high- pressure pumps are disposed in the fuel circuit, and that all the high-pressure pumps are triggered independently of one another via a common pressure regulating circuit.

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION

Page 1, between the title and paragraph [0001]:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This application is a 35 U.S.C. 371 application of PCT/DE 01/01720, filed May 8, 2001.

[0000.6] BACKGROUND OF THE INVENTION

paragraph [0001],:

[0001] [Prior Art] Field Of The Invention

Page 3, between paragraphs [0005] and [0006]:

[0005.5] DESCRIPTION OF THE PRIOR ART

Page 7, paragraph [0013]:

[0013] [Advantages of the Invention] SUMMARY OF THE INVENTION

Page 12, deleted paragraph [0024]:

[0024] [Based on the direct-injection internal combustion engine of the type defined at the outset, it is further proposed, for attaining the object of the present invention, that the fuel metering system is embodied in accordance with one of claims 5-9.]

Page 14, paragraph [0030]:

[0030] [Drawing] BRIEF DESCRIPTION OF THE DRAWINGS

paragraph [0031]:

[0031] Further characteristics, possible applications, and advantages of the invention will become apparent from the ensuing description of exemplary embodiments of the invention,[which are shown in the drawing. All the characteristics shown or described individually or in arbitrary combination form the subject of the invention, regardless of how they are combined in the claims or their dependency and regardless of their wording or illustration in the specification and the drawing. Shown are:] taken in conjunction with the drawings, in which:

Page 15, between paragraphs [0037] and [0038]:

[0037.5] DESCRIPTION OF THE PREFERRED EMBODIMENTS

Page 17, paragraph [0042]:

[0042] The high-pressure reservoir 16 is embodied as a storage strip of a common rail (CR) fuel metering system. A pressure sensor is disposed on the high-pressure reservoir 16; it detects the injection pressure prevailing in the high- pressure reservoir 16 and generates a corresponding output signal [p_r] P_r. From the high-pressure reservoir 16, a plurality of injection valves 9 - in the present case, four of them - branch off, by way of which fuel is injected into the combustion chambers 4 of the cylinders 3 of the engine 1. For injection of fuel, the injection valves 9 are triggered by a suitable trigger signal ES. The spark plug 10 is triggered by a trigger signal ZW.

Page 20, paragraph [0048]:

[0048] Both high-pressure pumps 14, 15 are disposed in this single fuel circuit. Both high-pressure pumps 14, 15 are triggered independently of one another by the control unit 22 via a common pressure regulating circuit. For economy of operation, in terms of resources, of the fuel metering system 11, both high-pressure pumps 14, 15 are triggered with the same triggering time signal T. The triggering time signal T is accordingly calculated once and for all in the control unit 22 for both high-pressure pumps 14, 15.

Page 22, paragraph [0053]:

[0053] Fig. 3 shows a triggering of the high-pressure pumps 14, 15 of the fuel metering system [1] 11 of Fig. 2 in accordance with a preferred embodiment. In the upper half of Fig. 3, the stroke [h_1] h_1 of the high-pressure pump 14 is shown, and in the lower part, the stroke [h_2] h_2 of the high-pressure pump 15 is shown. It is clearly seen that the two high-pressure pumps 14, 15 are triggered oppositely from one another. It can also be learned from Fig. 3 when the pump pistons of the high-pressure pumps 14, 15 execute an intake stroke, or when they pump fuel into the high-pressure reservoir 16 in a pumping stroke.

Page 24, after paragraph [0055]:

[0056] The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

[Abstract] ABSTRACT OF THE DISCLOSURE

The present invention relates to a method for operating a fuel metering system [(11)] of a direct-injection internal combustion engine [(1)], having a fuel supply container [(12)], at least one prefeed pump [(13)], a high-pressure pump assembly having at least two high-pressure pumps [(14, 15)] for pumping fuel out of the low-pressure region [(ND)] into at least one high-pressure reservoir [(16; 16', 16")], a control unit [(22]) for regulating an injection pressure [(p_r)] prevailing in the high-pressure reservoir [(16; 16', 16")], and having fuel injection valves [(9)] for injecting fuel out of the high- pressure reservoir [(16; 16', 16")] into combustion chambers [(4)] of the engine [(1)]. In order especially in engines [(1)] with large displacement and in engines with more than four cylinders to assure reliable supply of fuel to the combustion chambers [(4)], it is proposed that the fuel metering system [(11)] has one fuel circuit for metering fuel into all the combustion chambers [(4)] of the engine (1), and all the high- pressure pumps [(14, 15)] are disposed in the fuel circuit, and that all the high-pressure pumps [(14, 15)] are triggered independently of one another via a common pressure regulating circuit. [(Fig. 1)]